GEOMETRIC PROPERTIES OF POSSIBLE VOLCANOES IN THE SOUTH POLAR REGION, MARS

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Introduction: In 1987 Tanaka and Scott mapped the south polar region of Mars using Viking Orbiter data and identified several features as volcanoes, probable volcanoes of uncertain origin, or mountains of uncertain origin [1]. Several workers have since studied these features using Mars Orbiter Laser Altimetry (MOLA) data [2-4]. In the north polar region of Mars volcanic edifices have been identified [5,6] that have surrounding annular depressions, perhaps formed when magma chamber heat melted surrounding ground ice causing surface subsidence [7]. Our objective is to use Martian south polar volcanoes as indicators of magma-ground ice interactions and as indicators of regional eruptive styles. In this study we use high resolution MOLA data to characterize the geometric parameters of mapped volcanoes and mountains and systematically search for any unidentified volcanic edifices from latitude 55° S to the South Pole.

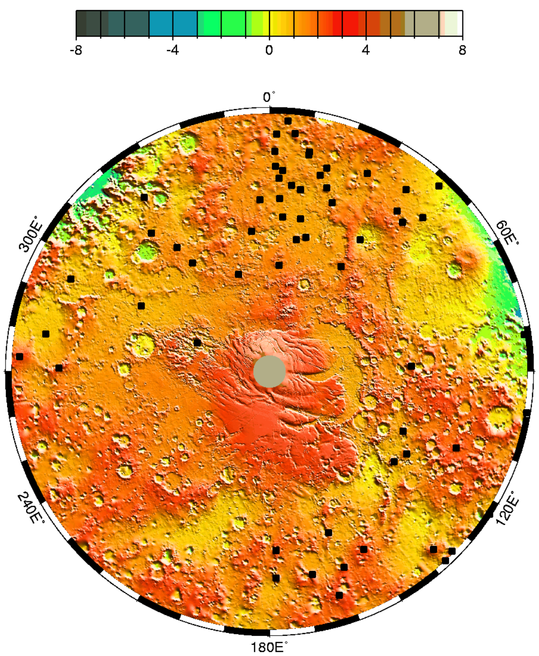

Figure 1. Polar stereographic projection of topography from MOLA data (credit: MOLA Science Team), latitude 55°S to the South Pole, showing distribution of all features studied.

Methods: First, we surveyed a high resolution grid of MOLA data for all volcanoes and mountains of indeterminate origin mapped by Tanaka and Scott [1] and for any other possible volcanic edifices (Figure 1). We used criteria such as whether the feature has a discernable topographic rise, distinct summit area, radial symmetry, conical shape, summit crater or vent structure, radial flow texture, surrounding topographic depression, and association with other known volcanic features. We then created local crossover-corrected high resolution grids of MOLA data [8] in order to characterize the geometry of each edifice. Using the IDL-based program Gridview [e.g. 9], we took two profiles per edifice and measured the diameter, height, flank slope, summit slope, base elevation and summit crater diameter. Profiles were taken in N-S and E-W orientations unless secondary modification (e.g. an impact crater) mandated use of a different alignment (needed in ~13% of cases). Using our criteria we placed each of the features studied into one of six classifications: volcano, probable volcano, possible, enigmatic, improbable, and highly unlikely (Figure 2).

We graphed Volume/Diameter (V/D) versus average flank slope for all features measured (Figure 3). V/D is a measure of volcanic productivity or amount of volume in a footprint of a certain size [5]. Convex-downward shapes produce higher V/D values than simple cones or features with convex upward slopes.

Results and Discussion: We have identified 12 additional features as probable volcanoes, 7 of which were identified previously as mountains. Several of these have surrounding depressions that may indicate magma – ground ice interactions (Figure 2). We identified 14 features as possible volcanoes, several of which also have surrounding topographic depressions.

We also identified 20 features as enigmatic, six as improbable, and four as highly unlikely to be of volcanic origin. Several other features were placed in the previous three categories but are not included in the dataset or used as data points in our graph of V/D versus flank slope because post-emplacement modification does not permit accurate volume measurements.

Finally, one feature previously mapped as a volcano (66S, 160E) we classified as a possible volcano, while another previously mapped volcano (72S, 170E) we classified as highly unlikely to be a volcano because it does not appear in high resolution MOLA data. As such it is not shown on the graph in Figure 3.

Of the probable volcanoes, 7 are in Ghatan and Head's study area [4]. They suggest a subglacial volcanic origin for these and other mountainous features in the region. We identify the 14 other edifices included in their study as possible volcanoes, enigmatic features, or improbable volcanoes.

From our graph of volcanic productivity, (Figure 3) there are no distinctive groupings based on our classifications. The probable and possible volcano data points fall beneath the data points from the mapped volcanoes, however many of the enigmatic features also fall within this range, as do two of the features that are improbable volcanoes.

Seven features included in our dataset, given their geometry and association with impact craters, appear to be central crater peaks with summit craters. We graphed these separately from the other enigmatic features and from the graph can see that they have similar flank slopes but differ in shape (volume/diameter). Further study is needed to determine whether these features are or are not volcanic.

While we could not glean information from the Volume/Diameter graph about whether the features are volcanic in origin because of the wide spread in the data, we were able to compare our V/D versus flank slope data with that from a study [2] of north polar volcanoes. From this comparison we conclude that the mapped volcanoes, probable volcanoes, and possible volcanoes in the south polar region are larger, farther apart, and appear to be more convex (downward) than the north polar volcanoes. They are more similar in shape than the north polar volcanoes to the largest Martian shield volcanoes such as Olympus Mons.

Conclusion: There are probably 12 more volcanic edifices in the south polar region than previously mapped, and perhaps more. Further study of these features using image data is needed to make any more definitive statements about their origins. While volume/diameter has been used to confirm identification of north polar volcanoes, to first order it does not appear to discriminate volcanic from non-volcanic edifices in the south polar region. Some of the likely volcanic candidates have annular depressions similar to some small north polar volcanoes, suggestive of magma chamber and ground ice interactions. In general shape, the south polar volcanoes, probable volcanoes, and possible volcanoes are larger, farther apart, and have more of a convex downward shape than the north polar volcanoes. Further study is needed to understand what caused this shape difference and what influenced feature distribution in the south polar region.

References: [1] Tanaka, K.L. and Scott C. D. (1987) Geologic Investigations Series, US Geological Survey, Geologic Map of the Polar Regions of Mars. [2] Sakimoto, S.E.H. et al. (2002) *LPSC XXXIII*, Abstract #1717. [3] Tanaka, K.L., and Kolb, (2001) *Icarus, 154,* 3-21. [4] Ghatan, G.J. and Head J.W. (2002) *JGR, 107 (E7),* 5048, 10.1029/2001JE001519. [5] Garvin, J.B et al. (2000) *Icarus, 145,* 648-652 [6] Sakimoto, S.E.H et al. (2001) *LPSC XXXII,* Abstract # 1808. [7] Grosfils, E.B. and Sakimoto, S.E.H. (2001) *LPSC XXXII,* Abstract #1111. [8] Neumann, G.A. et al. (2001) *JGR, 106*, 23573-23768. [9] Roark, J. et al. (2001) *LPSC XXXII*, Abstract # 1618.

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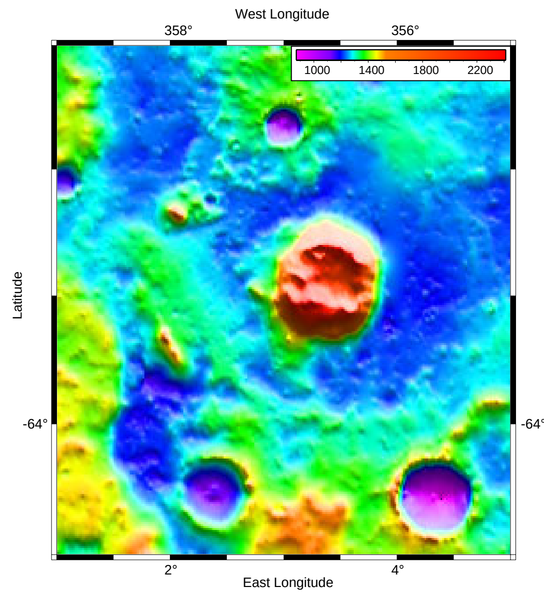

Figure 2. Example of a feature we identify as a probable volcano, previously identified as a mountain. Topographic depression surrounds the feature, perhaps a result of ground ice and magma interaction.

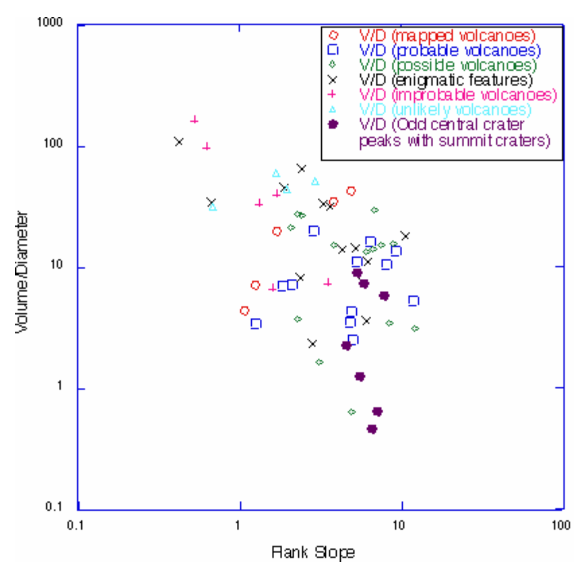

Figure 3. Graph of Volume/Diameter versus flank slope, with log scales.